Instruction Manual

JOHN FLUKE MFG. CO., INC.

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ELECTRONICS FOR INDUSTRY

INSTRUMENTS / COMPONENTS

JOHN FLUKE MANUFACTURING CO, INC.

P.O. BOX 7428, SEATTLE 33, WASHINGTON

OPERATING INSTRUCTIONS

MODEL 101 VAW METER

S/n — 130 + on

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JOHN FLUKE MFG. CO., INC.
P. O. BOX 7161
SEATTLE 33, WASH.

MODEL 101 VAW METER

Operating Instructions

FOR THE MEASUREMENT OF VOLTS, AMPERES AND WATTS OVER WIDE RANGES AND AT FREQUENCIES OF 20 TO 200,000 CPS

The Model 101 VAW Meter is a highly useful instrument for the measurement of a-c Volts, Amperes and Watts from low audio through supersonic frequencies. This unique instrument, with its high input impedance, its small size, its accuracy and simplicity and its wide range of measurement of Volts, Amperes and Watts over this extended frequency range, provides an indisputably outstanding measuring device for a-c measurements in the electrical and electronic fields.

MODEL 101 VAW METER

Electrical Specifications

Voltage Ranges (8): .1, .3, 1, 3, 10, 30, 100, 300 RMS Volts

Ampere Ranges (10): .001, .003, .01, .03, .1, .3, 1, 3, 10, 30 RMS Amperes

Watt Ranges:

	AMPERES									
	.001	.003	.01	.03	.1	.3	1	3	10	30
.1	.0001	.0003	.001	.003	.01	.03	.1	.3	1	3
.3	.0003	.0009	.003	.009	.03	.09	.3	.9	3	9
1	.001	.003	.01	.03	.1	.3	1	3	10	30
3	.003	.009	.03	.09	.3	.9	3	9	30	90
10	.01	.03	.1	.3	1	3	10	30	100	300
30	.03	.09	.3	.9	3	9	30	90	300	900
100	.1	.3	1	3	10	30	100	300	1000	3000
300	.3	.9	3	9	30	90	300	900	3000	9000

Frequency Range: 20 to 200,000 cycles per second.

Overall Accuracy: Within plus or minus 3% of full scale value for any reading from 20 to 200,000 cps.

Volt and Ampere Readings: In terms of the average value of the rectified full sine wave.

Watt Readings: In terms of the product of RMS volts, RMS amperes and the cosine of their phase displacement angle (VA cos ϕ). If harmonics are present, readings will be sum of powers due to fundamental and harmonics.

Meter Calibration: Selectively reads RMS volts, RMS amperes or watts.

Scales: All scales are linear. Scale arcs graduated 0-10, 0-9, 0-3.

Input Shunt Impedances: Input capacity approximately 25 mmfd.
Input resistance 1 megohm on all voltage ranges.

Drop at Shunts for full Scale Amperes: Five millivolts.

Overload Capacity: About 3 times on "A" and "W" ranges and 15 times on "V" range. Overload limited by voltage rating of input capacitors and current carrying capacity of terminals and shunts.

Regulated Power Supply: Line voltage variations from 105 to 130 volts at 60 cps cause less than 1% variation in readings.

Power Requirements: 117 volts, 50-60 cps, 1.05 amperes, 105 watts. Power transformer tapped at 105 volts.

Electrical Specifications (Cont.)

Fuse Rating: Three Amperes

Mechanical Specifications

Weight: 27 pounds

Dimensions: 10" high, 12" deep, 16" wide (less handles and knobs).

Finish: Baked gray wrinkle enamel, smooth gray on front panel.

MODEL 101 VAW METER

OPERATING INSTRUCTIONS

Before initially operating the Model 101 VAW Meter make certain that the meter pointer is set on zero and that the instrument has not been damaged in transit. Connect the power cord to an appropriate power source and turn the power switch to the "ON" position. Allow four to five minutes for the instrument to warm up. Set the selector switch to "W" and rotate the "W ZERO" knob (small knob in center botton of panel) until the meter pointer is on zero. This zero adjustor is effective for the wattmeter ranges only. Once it has been set very little future adjustment will be required. Particularly is this true if adjustment is made after the instrument is well warmed (10 to 15 minutes).

The selector switch (VAW) should be set to "V" during changing of the shunts. During switching of the voltage range switch or changing shunts a transient deflection of the meter pointer will take place. This condition is normal and does not indicate malfunctioning of the instrument. Switching the voltage range switch or changing shunts with the VAW switch in other than the "V" position may cause the transient deflections of the meter pointer to be more violent than with the VAW switch in the "V" position.

It is desirable, notwithstanding the overload capacity inherent in this instrument, to set the voltage range switch to one of the higher ranges prior to connection to a source of unknown voltage. A shunt for the current range should always be selected so that a shunt of sufficiently high range is used. In general, the shunt rating should never be exceeded by more than three times.

If the ground terminal (terminal marked "G") is connected to a potential above ground, adequate precautions should be taken to insulate the instrument case from surrounding objects and personnel since the "G" terminal is connected internally to the case.

In connecting the instrument in a circuit whose voltage, current and power are to be measured the terminal "G" should be connected to the grounded side of the power source, one of the terminals marked "H" to the high side of the power source and the other terminal "H" and the terminal "L" to the load. The two terminals "H" are bussed together inside the instrument. These connections are shown in Figure 1.

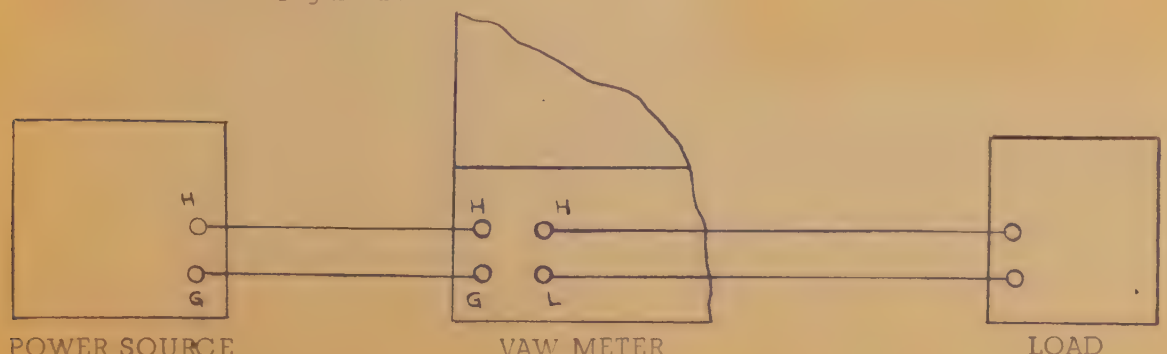


Figure 1.

Obviously the load should not be grounded, otherwise the shunt will be short circuited by the dual grounding of the load and generator. If the generator is ungrounded and the load grounded, then the connections to the "L" and "G" terminals should be interchanged. Though no dual grounding exists, capacity to ground of the load should be kept low to prevent its reactance at the circuit frequency from appreciably shunting the ammeter shunt element. Since the resistance of the shunts is small, appreciable capacity to ground must be present to cause any error.

Where both the load and generator must be grounded it is necessary to isolate the two grounds electrically. This may be accomplished through the use of a transformer as shown in Figure 2. Here again, however, the transformer winding must not have sufficient capacity to ground to prevent its reactance at the circuit frequency from appreciably shunting the ammeter shunt element.

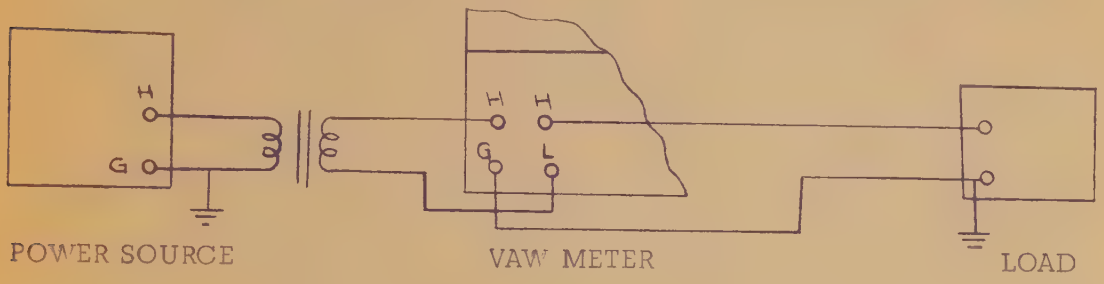


Figure 2.

INPUT IMPEDANCE AND SHUNT RESISTANCE

The ohmic values of the shunts available are tabulated in Table I.

TABLE I.

Resistance of Shunts

Range in Amperes:	.001	.003	.01	.03	.1	.3	1	3	10	30
Resistance of Shunt in ohms:	5	1.667	.5	.1667	.05	.01667	.005	.001667	.0005	.0001667

The input impedance imposed across the circuit by the VAW METER is constant at one megohm for all voltage ranges. In parallel with this resistance there is a capacitance of approximately 25 uufd.

It should be noted that while the shunt drop is 5 millivolts this drop is that occuring at rated shunt current at the ends of the shunt resistor where the current proportional voltage is derived. Between the terminals "G" and "L" the drop may exceed this value at frequencies above approximately 20 kc for the higher current

shunts. This excess voltage drop is due primarily to the reactance of the short busses inside the instrument reaching a maximum of about 35 millivolts between the "G" and "L" binding posts for the 30 ampere shunt at its rated current at 200 kc.

CALIBRATION

The volt and ampere ranges of the Model 101 VAW Meter are calibrated to read the root-mean-square (RMS) value of a sine wave. The voltmeter and ammeter, however, are responsive to the average value of the rectified full wave. Thus if the voltage or current waves are pure sine waves there are no errors due to waveform in the volt or ampere readings. If harmonics are present the resulting error is dependent both on the number, magnitude and phase relationships of the harmonics. While it may be difficult or impossible to determine all these factors, it is helpful to know the maximum error which can be present. This information is given for several cases in Table II.

TABLE II.

% Harmonic	Actual RMS Value	Model 101 "V" or "A" Reading	Peak Meter Reading
0	100	100	100
10% 2nd	100.5	100	90-100
20% 2nd	102	100-102	80-120
50% 2nd	112	100-110	75-150
10% 3rd	100.5	96-104	90-110
20% 3rd	102	94-108	82-120
50% 3rd	112	90-116	108-150

The wattmeter readings are a product of volts, amperes and the cosine of the angle of their relative phase displacement, or $W = VA \cos \phi$. There is inherently no harmonic error in the wattmeter reading. Consequently, the wattmeter will read the sum of the quantities $V_n A_n \cos \phi_n$ where the subscripts "n" denote corresponding fundamental and harmonic quantities. Therefore, for voltage and current inputs to the Model 101 VAW Meter which contain harmonics and where the load is resistive, multiplication of the "V" and "A" readings will not necessarily give a product equal to the "W" reading.

At low frequencies, in the 20 cycle region, the meter pointer will tend to oscillate slightly when on the "W" range. This condition is normal and does not indicate malfunctioning.

CIRCUIT DESCRIPTION

The instrument is comprised, in general, of two amplifier channels, networks for deriving signals proportional to circuit voltage and current, a multiplying element, a panel meter and a power supply for supplying direct current power.

In more detail, the signal proportional to circuit voltage is modified suitably in amplitude and applied to a feedback amplifier composed of tubes V1 and V2 shown on the wiring diagram in the back of this instruction book. The signal proportional to circuit current is derived from a shunt and amplified by tubes V12 and V11 operated as a feedback amplifier. The output of V11 is made available as amplified and also inverted in phase by tube V9 for further use in the instrument.

In the measurement of circuit volts by the VAW Meter the signal appearing at the output of V2 is applied to a feedback amplifier comprised of tubes V3 and V4. The output of this amplifier is rectified by RE1 and RE2, two germanium diodes arranged for full wave rectification, and applied to the d-c panel meter M.

For measuring circuit amperes with the VAW Meter the output of the phase inverter is applied to a feedback amplifier consisting of V8 and V7. The output of this amplifier is rectified by RE1 and RE2 and applied to the panel meter in the same manner as for measuring volts.

Selection of the circuitry for accomplishing the previously described readings of volts and amperes is accomplished by the several sections of switch S1 which is the "VAW" switch. This same switch is also used to establish the appropriate circuits for measuring watts. In the measurement of watts the outputs of tubes V2, V9 and V11 are applied to two tubes, V10 and V20, which produce two outputs one of which is applied to amplifier V3 and V4 and the other applied to amplifier V8 and V7. The outputs of these two amplifiers are respectively applied to power amplifiers V5 and V6 whose output, in turn, is applied to the wattmeter element "S". The output of "S" is applied to the panel meter to accomplish a reading of circuit watts.

All amplifiers and appropriate circuit components are designed, constructed and adjusted to reproduce the input signals with substantially flat response in both amplitude and phase throughout the rated frequency range. It will be observed from the wiring diagram that compensating capacity is liberally used to obtain good amplitude and phase response. It is essential in servicing the instrument not to rearrange or disturb portions of the circuit containing these trimming capacities since such will result in creating reading errors at the higher frequencies. Also, the wattmeter element "S", which is solder-sealed and liquid filled, should not be disturbed. Tampering with this unit may result in errors in the watts readings. There are no thermal elements, moving parts, vacuum tubes, or rectifiers in the wattmeter element. Its construction is such as to require no replacement under even severe operating conditions. It is entirely unsusceptible to overload and will normally retain its excellent accuracy indefinitely if not unsealed. The wattmeter element will withstand mechanical shocks of such force as to severely damage the remainder of the instrument. No responsibility for the proper functioning of the instrument is assumed after any attempt to unseal the wattmeter element. Should trouble develop which is thought to be traceable to the wattmeter element, it is highly recommended that the instrument be returned to the factory for check. This

service, recalibration of the instrument or repair and recalibration will be performed at the factory at a very nominal charge covering only direct labor and replacement components involved.

It will be noted that all plate power requirements of the amplifiers are supplied through a regulated power supply. This power supply possesses excellent regulation and the very low effective impedance (internal) of about .01 ohm. The power transformer is arranged to supply the filaments of tubes V1 through V12 from one secondary, and the rectifier tube filament from another secondary. Two more low voltage secondaries supply the filaments of the regulator amplifier, V14 and the series tube, V16. A high voltage secondary is also provided whose output is rectified by V17, filtered by a pi LC network, and applied to the regulator. The regulator is comprised of four tubes V13, V14, V15 and V16. V15 establishes a reference voltage which is compared to the output of the regulator dropped to a more usable level by a second regulator tube, V13. The voltage difference thus obtained is applied to a two stage, direct coupled amplifier tube V14. Owing to the high gain of this amplifier and because nearly the entire amplitude of any attempted fluctuation of the regulator output voltage is applied directly to the input of V14, a very good degree of regulation, with the resultant low effective internal impedance, is obtained by the high degree of control of V14 on the series regulator tube V16.

The shunts available with the VAW Meter are adjusted to have a constant resistance drop throughout their rated frequency range. The adjustment is dependent on the physical arrangement of the wiring inside the shunt case; consequently, it is important that this wiring not be disturbed if the introduction of shunt errors at the upper frequencies is to be avoided.

Regulation of filament currents to all amplifier tubes (V1 - V12) is effected through the use of ballast tubes V18 and V19 which maintain this current substantially constant for line voltage variations in excess of 105 to 130 volts. This regulation practically eliminates variation in amplifier gain due to fluctuating heater temperatures. This feature also simplifies requirements of replacement tubes since they need not be selected as critically for constant emission-temperature characteristics as would otherwise be necessary were heater current regulation not employed.

In servicing the instrument care should be taken that the adjustment of the trimmer capacitors and resistors are not disturbed. It is not satisfactory to judge the proper adjustment of these capacitors and resistors from measurements of voltage amplitudes alone. Phase measurements must be employed [illegible] to obtain accurate wattmeter readings when the trimmers in the circuit are adjusted.

APPLICATIONS

The Model 101 VAW Meter has been designed as a general purpose instrument capable of a wide range of measurements. Its high input impedance of one megohm and its low shunt drop will cause substantially no disturbance to most circuits to which it may be connected.

Figure 1 shows the usual method of connecting the VAW Meter where only the generator is grounded, and where the load is ungrounded. Where the generator is ungrounded and the load grounded the "G" and "L" connections shown in Figure 1 should be reversed. When both load and generator are grounded, it is necessary that advantage be taken of any transformer in the circuit, or that an auxiliary transformer be used, in the manner shown in Figure 2. Obviously, if an auxiliary transformer is used it must be capable of operating at the required voltage and power level, and over the frequency range at which measurements are to be made. At the higher frequencies, care must be taken that the capacity to ground of the transformer secondary is low enough to prevent appreciable shunting of the instrument shunt.

Aside from numerous special applications, the VAW Meter fills two general, broad purposes. The first is the measurement of voltage, current and power output of a power source. This power source may be a generator, oscillator or amplifier. Whatever the load supplied by the a-c power source, the VAW Meter provides a convenient, accurate means of measuring the output of such source into its normal load. Thus, it is possible to determine directly both volt-ampere and watt output of a power source into its normal load over a wide frequency range and over wide ranges in level of voltage and power. This feature is of particular value in measuring the output of amplifiers working into the loads for which they were designed rather than resorting to a known dummy resistive load heretofore available as the only general means of measuring amplifier output. Because of the negligible circuit loading imposed by the VAW Meter, it will be found that power outputs of relatively high impedance sources can be measured with accuracy. The frequency response of the instrument is such as to cover the entire audio range as well as the supersonic frequencies.

The second purpose filled by the VAW Meter is the measurement of the characteristics of nearly all types of networks over far greater ranges of level than that generally possible with bridge methods. Since the instrument measures volts, amperes and watts into a load, it is a simple matter, utilizing these measurements, to calculate the vector impedance of the load. In setting up to make these measurements a suitable source of power is required to supply the loads. It is apparent that the power source should cover the frequency range required, that it should have adequate power output and that it should be free from distortion in order that waveform errors not be introduced into the volt, and ampere readings on the VAW Meter. In general, the power source for this type of measurement will be either a rotating type generator or, more usually, an oscillator. Most oscillators commercially available will deliver several

watts output at about ten to forty volts. Excellent oscillators for this purpose are manufactured by the Hewlett-Packard Co., of Palo Alto, California. Where power output, in excess of that available from an oscillator, is required it will be necessary to use a suitable amplifier.

From the voltage current and power readings obtained from the VAW Meter, the impedance characteristics of the load being measured may be determined in the following manner. Let the symbols V, A and W represent the readings of volts, amperes and watts obtained from the VAW Meter. Also, let ϕ be the phase angle in degrees measuring the angular displacement between V and A.

Then the power delivered to the load is W and the volt-amperes delivered to the load are (V) (A).

The phase angle is obtained from:

$$\cos \phi = \frac{W}{VA} \tag{1}$$

$$\text{or } \phi = \cos^{-1} \frac{W}{VA} \tag{2}$$

The scalar value of load impedance is, in ohms:

$$|Z| = \frac{V}{A} \tag{3}$$

The load resistance is:

$$R = |Z| \cos \phi \tag{4}$$

The load reactance is:

$$X = |Z| \sin \phi \tag{5}$$

Equations (4) and (5) may be combined to read:

$$Z = R \pm jX = |Z| \ (\cos \phi \pm j \sin \phi) \tag{6}$$

The sign to be used in equation (6) may be determined from a knowledge of the load characteristics as to whether it is predominantly inductively reactive or capacitively reactive. For the former, the plus sign is used and equation (6) becomes

$$Z = R + jX = |Z| \ (\cos \phi + j \sin \phi) \tag{7}$$

If capacitive reactance predominates, equation (6) becomes

$$Z = R - jX = |Z| \ (\cos \phi - j \sin \phi) \qquad (8)$$

The reactive sign may also be determined by introducing additional reactance across the load. If additional inductance makes the reading of W more nearly equal to the product of (V) (A), then the load is predominantly capacitive in its reactance component. If additional capacitance across the load makes the reading of W more nearly equal to the product of (V) (A), then the load is predominantly inductive in its reactive component. Care must be exercised in the introduction of additional inductance to prevent the drawing of false conclusions through the use of an inductance with excessive losses. Usually it is more satisfactory to use an additional capacity since capacitors with essentially zero loss are generally available in a wide range of values.

The Model 101 VAW Meter will be found to be useful in a number of circuit arrangements for the measurement of power and volt-ampere outputs as well as in the measurement of load characteristics and load or transmission losses. A few of the uses of the instrument, in this respect, are listed below.

1. Measurement of generator, amplifier or oscillator outputs into any desired load over the range of 20 cps to 200 kc.

2. Measurement of inputs and outputs of transmission lines and networks and, consequently, their power loss.

3. Measurement of exciting requirements and losses in transformers, the measurement of power losses in loaded transformers and the measurement of quantities from which the impedance characteristics of transformers may be calculated.

4. Measurement of power input to loads such as loudspeakers working from the amplifiers with which they are to be used, or for measuring loudspeaker characteristics as a function of radiated energy over various ranges of frequency and output level.

5. Measurement of inductor characteristics at various frequencies with, or without, direct current flowing in the inductor windings.

MAINTENANCE

The components used in the Model 101 VAW Meter have been selected with the view of providing long, trouble-free operation. High quality components have been employed to achieve this end. Parts are well separated to provide for the maximum ease of inspection consistent with the need for adequate shielding of low level circuits and the minimizing of stray circuit capacities. Replacement of tubes at infrequent intervals will probably constitute the only service item in the instrument. Even here, however, the tubes should not be hi in view of their conservative use in this device. Worn tubes may

placed, insignificant changes in calibration should result when the tubes are of normal tolerance owing to the feedback used on all amplifiers. Substandard tubes may affect the calibration somewhat. Also, some tubes may draw excessive grid current or they may have appreciable heater-cathode leakage. The latter evidences itself in a permanent deflection of the meter pointer on either the A or V ranges when the input terminals are shorted together. Any tube producing a permanent delfection should not be used. Low leakage is, of course, more important on the low level stages where the signals derived from such leakage are amplified by successive stages. Consequently, the leakage requirements for V1, V2, V12, V11 and V10 are the most severe. Of these, V12 is the most critical. This information is given as a precautionary guide in tube replacement and does not indicate that the tube requirements are excessively severe. Usually, no trouble will be experienced in satisfactorily replacing tubes.

Since all amplifiers are operated from the same power supply through a common regulator, it is necessary that the regulator function properly to maintain stability of the instrument readings. Failure of the regulator usually evidences itself either in the inability of the instrument to read, or in transient meter deflection (motor-boating). The former condition is due to a burned out rectifier, V17, or a defective regulator tube, V16, preventing the application of direct voltage to the amplifiers. Under normal conditions the regulator output is about 245 volts d-c.

Motor-boating is usually caused by defective regulator tubes (V13 or V15) or by a defective amplifier tube, V14.

Also, failure of the instrument to read may be caused by a burned out fuse. This condition is readily indicated by the absence of meter illumination. The fuse is located in a fuse holder, conveniently located on the lower right-hand corner of the front panel. A three ampere fuse should always be used as a replacement if proper protection of the instrument is to be maintained. If a fuse burns out it is always advisable to determine the reason for fuse rupture rather than to simply replace the tube without further investigation.

Calibration of the instrument may be checked in the following manner. First check the calibration of the V range, at a convenient range switch setting, against a known voltage measured by an accurate meter, by a calibrated oscilloscope or by the drop across a standard resistor, the current through which is measured by an accurate ammeter or thermo ammeter.

The current range, A, may be checked against an accurate ammeter or thermo ammeter.

The W readings can be then checked utilizing a purely resistive load utilizing an ammeter. The W reading should equal I^2R. Or the W reading should be the equivalent of (V) (A) for a resistive load excited from a sinusoidal voltage source.

The ability of the wattmeter to read zero power factor may be checked by utilizing a high quality capacitor, of suitable capacity at the frequency used, as a load.

It is emphasized that instrument wiring associated with trimmer capacitors and the trimmer capacitors themselves, be left undisturbed in order that the accuracy of the instrument be unimpaired at the higher frequencies. Adjustment of the trimmer capacitors has no affect on calibration below a frequency of approximately 20 kc, consequently, their adjustment will be of no value in any attempt at correcting any error thought to exist at the lower frequencies.

Two 6.3 volt miniature bayonet base lamps for illuminating the meter scale, and which also serve as pilot lights, are accessible from the rear of the front panel. The sockets for these lights are friction held in place by spring pressure in transparent plastic cups in the meter case. Removal of the sockets for lamp replacements may be effected by gently pulling the sockets from the plastic cups.

The John Fluke Mfg. Co., Inc. will recalibrate any Model 101 VAW Meter at cost, on a quick service basis, which is returned-prepaid to the factory. The same service is offered on any repairs or replacements that may be required. Normally, the equipment required for complete recalibration of the instrument is not available to most users because of the specialized nature of such apparatus. Consequently, it will be found both economical and expedient to return the instrument to the factory for calibration or repair. Particularly is this true when it is considered that accurate calibration is dependent on more accurate calibration equipment and upon calibration technique.

Much effort has been exerted to build long life into the Model 101 VAW Meter by using quality components, conservative design and rugged construction to provide you with an instrument which is reliable, easily read, convenient to use and capable of providing many years of satisfactory service. It is believed that these objectives have been achieved. Reasonable care in operation and handling the instrument will assist materially in prolonging its service to you.

WARRANTY

The JOHN FLUKE MFG. CO., INC. warrants each instrument manufactured by them to be free from defects in material and workmanship. Their obligation under this Warranty is limited to servicing or adjusting an instrument returned to the factory for that purpose, and to making good at the factory any part or parts thereof; except tubes, fuses, choppers and batteries, which shall, within one year after making delivery to the original purchaser, be returned by the original purchaser with transportation charges prepaid, and which upon their examination shall disclose to their satisfaction to have been thus defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at a nominal cost. In this case, an estimate will be submitted before work is started, if requested.

If any fault develops, the following steps should be taken.

1. Notify the John Fluke Mfg. Co., Inc., giving full details of the difficulty, and include the Model number, type number, and serial number. On receipt of this information, service data or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the Warranty.

SHIPPING

All shipments of John Fluke Mfg. Co., Inc. instruments should be made via Railway Express prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

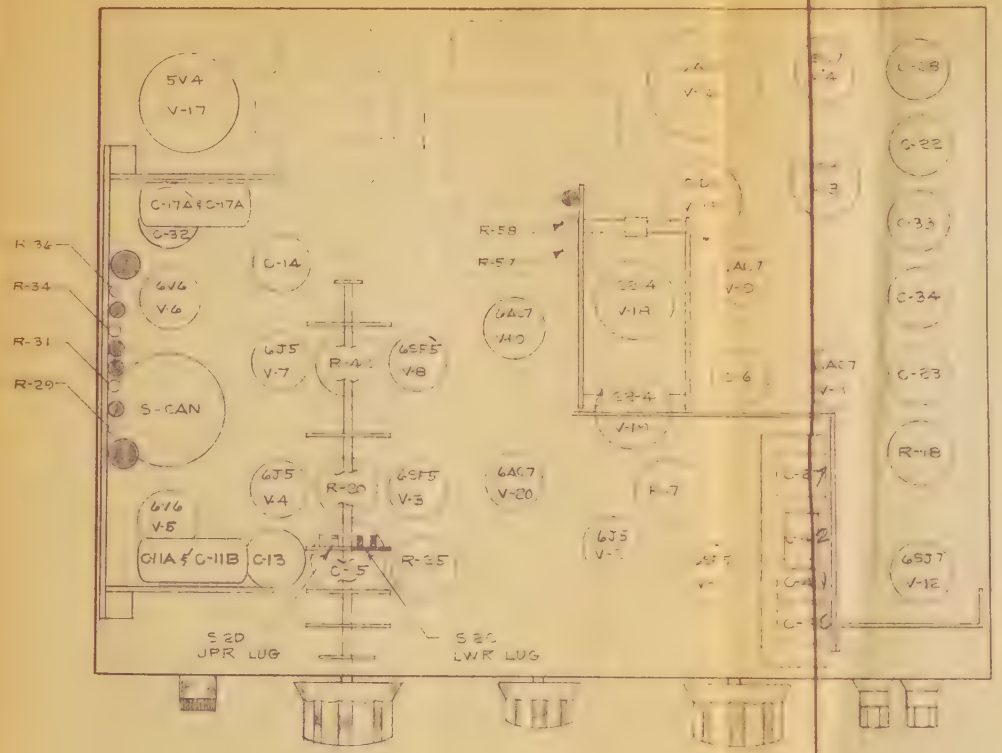
CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be thoroughly inspected immediately upon receipt. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to John Fluke Mfg. Co., Inc. Upon receipt of this report you will be advised of the disposition of the equipment for repair or replacement. Include the model number, type number, and serial number when referring to this instrument for any reason.

The John Fluke Mfg. Co., Inc. will be happy to answer all application questions which will enhance your use of this instrument. Please address your requests to:

JOHN FLUKE MFG. CO., INC., P. O. BOX 7428, SEATTLE 33, WASHINGTON

DETAIL NO.	QUAN.	DESCRIPTION	J. F. STOCK NO.



NOTE:

- FOR COMPONENT ORIENTATION ONLY

REV	C/N	DESCRIPTION	DATE

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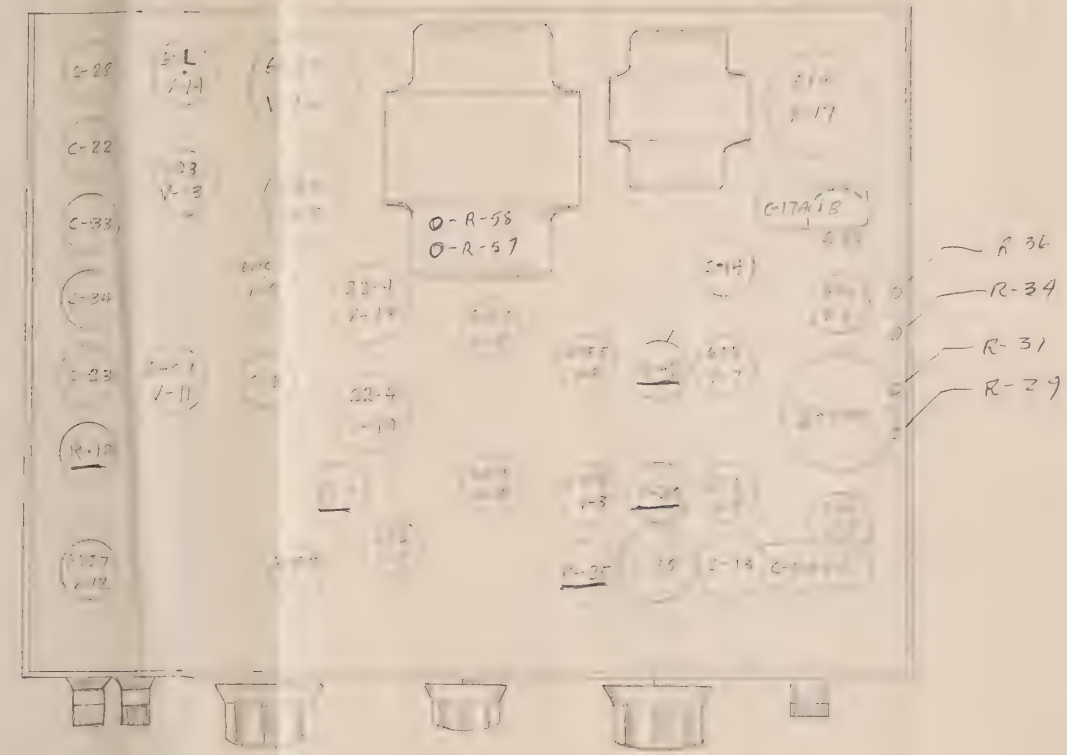
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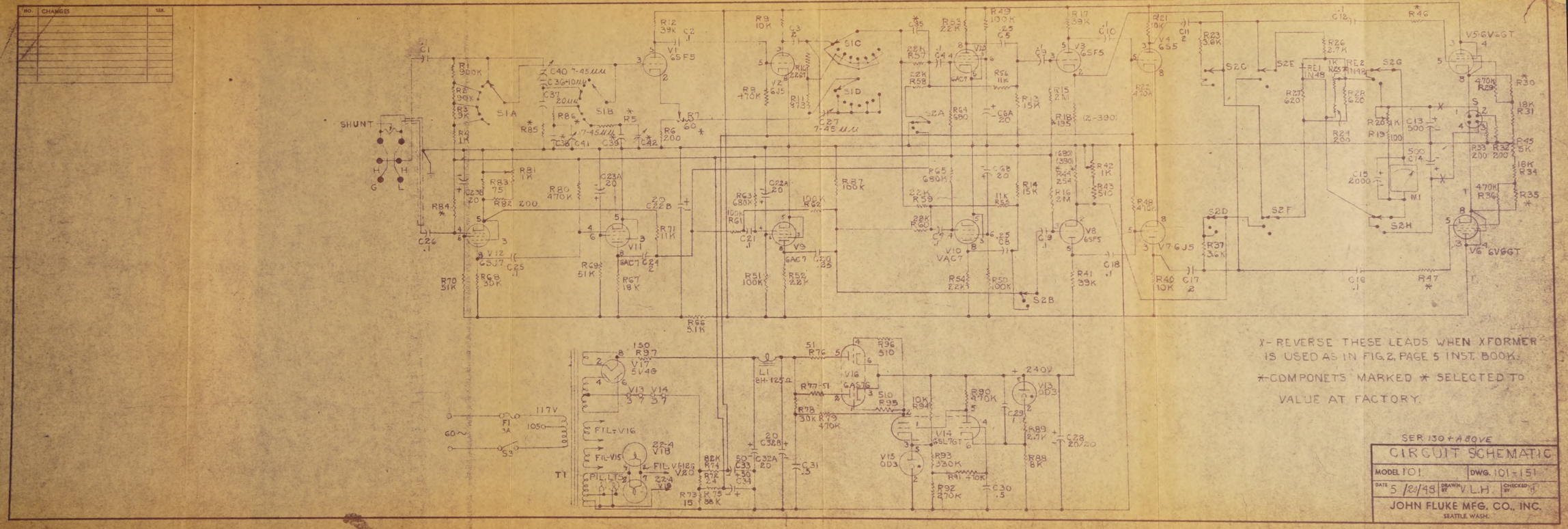

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